3. At the commencement of the disease it is, as a rule, impossible to say whether it will terminate favorably or become chronic.

4. The movements are generally most marked in the arms; they may begin in the lower extremities and, rarely, may remain confined thereto. In 20 per cent. of the cases in the table they were unilateral.

5. The mind is normal in three-fifths of the cases in which no hereditary element exists.

6. Rheumatism holds a very subordinate relation to the chorea of late adult life.

7. Endocarditis is comparatively rare, having occurred in only 12.3 per cent. of the cases collected in the table.

8. The anatomic lesions in the fatal cases are not characteristic.

DISINFECTION BY STEAM.

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THE rapid strides made in bacteriological work during the past ten years have given a stimulus, both in this country and abroad, to the study of disinfection and disinfectants. This has resulted in the accumulation of satisfactory and reliable data, which for the first time place this subject upon a scientific basis. The uncertainty which formerly existed regarding the value of various disinfectants and the manner of their application frequently brought sanitary methods into ridicule. This cannot be wondered at when we examine the long list of disinfectants which have from time to time been confidently recommended, and which we now know to be practically useless as germicidal agents. Fortunately, modern scientific investigation is gradually separating the valuable from the worthless disinfectants. We cannot justly criticise the former conclusions of the sanitarian, as his deductions regarding the value of disinfectants depended almost entirely upon the apparent success which followed their use during the prevalence of infectious diseases. The rapid subsidence of an outbreak was very apt to be attributed in a great measure to the use of certain disinfectants, and an undeserved reputation was frequently given to a worthless article. Today, with a fuller knowledge of the micro-organisms causing the different infectious diseases and the means of studying the effect of different agents upon them, we are enabled to decide with comparative accuracy as to the germicidal power of the latter. Although the experimental stage in the study of this subject may be said to be well advanced, yet the opportunities offered for further investigation in this direction are still great.

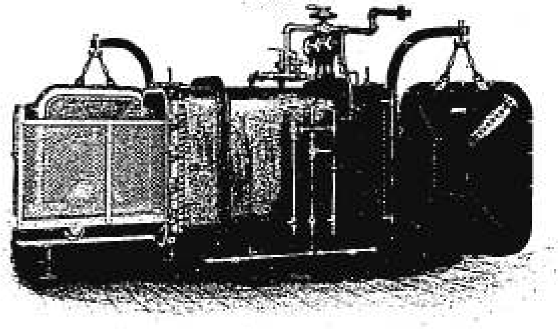
A substance which in the laboratory is germicidal to different micro-organisms with which it is brought in *direct* contact is not always an agent which can be depended upon in practical work. In the latter case the germs are usually not exposed, but are hidden in clothing, bedding, etc. Therefore the penetrating power of a disinfectant constitutes an exceedingly important consideration. Rapidity of action is also an important requisite, particularly in quarantine-work, as is likewise freedom from injurious effects upon delicate fabrics.

Appreciating the necessity of definite and reliable knowledge to guide us in practical work, I have conducted during the past year a series of experiments with some of the disinfectants now in use, and present in this article the results of the work as far as they concern steam.

There can be no diversity of opinion as to the superiority for many purposes of steam over all other disinfectants. The certainty of its germicidal effect, the rapidity of action, and its high penetrating power under proper conditions give it the highest rank. Unfortunately the cost of the apparatus necessary for its proper application limits its use mainly to quarantine and other public service. Although potent when intelligently employed, steam is worthless when improperly applied.

I can, perhaps, give no better idea of the modern perfected steam-chamber than by describing the apparatus for disinfection by steam now in use on the disinfecting-steamer "James W. Wadsworth," at the New York Quarantine Station. (Fig. 1.) This apparatus consists of a rectangular-shaped chamber having a double shell with a space of 2 inches between its walls. The inside dimensions of the chamber are 39 x 48 inches by 7 feet 2 inches long. The shells are made of $\frac{5}{16}$ inch

FIG. 1.



open-hearth flange steel, riveted at the ends to heavy cast-iron rings, the outer surfaces of which are indented and contain 1½-inch T-shaped rubber joints, for the purpose of making the doors steam-tight. The latter are of a convex type, are swung on cranes, and fastened to the chamber with turn-buckles. A car for the reception of material to be disinfected easily traverses the chamber. It is made of 1½-inch angle-iron and No. 6 galvanized iron netting. A movable track is so arranged that the car can be entirely withdrawn from either end of the chamber. The steam is supplied from the boiler of the steamer, where a pressure of 65 pounds to the square inch is maintained. Both moist and dry steam outlets have been constructed, which, by a system of valves, allow the operator to get almost any quality of steam desired. The steam enters through a 2½-inch pipe to a reducing valve, which limits the pressure of the steam entering the chamber of the apparatus to the desired amount; at the present time it is set for 15 pounds to the square inch. The pressure used in the chamber is in accordance with the temperature required. If a temperature of 230° to 250° F. is desired, steam at about 10 pounds pressure is employed.

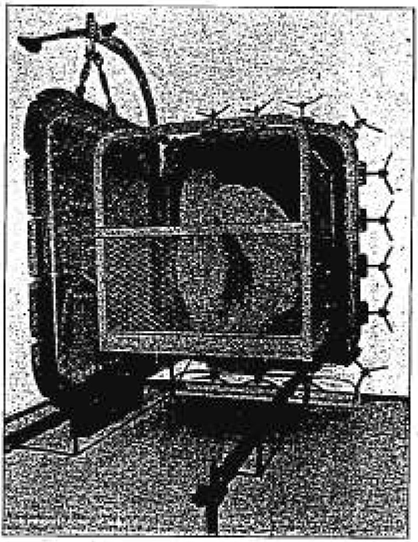
For obtaining a vacuum in the chamber a steam-exhauster is used. By means of valves this is readily changed to draw either from the space between the shells forming the walls, or from the interior of the chamber. It acts on the principle of a siphon: a current of steam rushing by the mouth of a pipe opening into the chamber exhausts the air therein contained.

A vacuum of 1½ atmospheres (about 22 or 23 inches) can be obtained with the steam-exhauster in one minute, while in the old method, by the use of a vacuum-pump, about ten or fifteen minutes were necessary to secure this result; besides, the air removed from the chamber is carried out with the steam in the exhaust, so that if micro-organisms are withdrawn in this way from the materials in the chamber they are acted upon by the steam in transit. This does not occur where a vacuum-pump is used.

The advantages of the double jacket or shell over coils of steam pipes are numerous. There is a more equal diffusion of heat in the walls of the apparatus, inasmuch as the steam enters between the shells at all points and not at the lower part of the apparatus, as in the case where the steam is introduced by pipes laid in the floor of the chamber. The shell is thus evenly heated and materially aids the steam which is introduced in the chamber for disinfection. Leaks are frequently found where the pipe system is employed; these do not occur when the double shell is used; there is no formation of air-bound spaces in the double shell, which frequently interfere with securing the temperature needed; and, finally, in the matter of cleanliness, the double jacket is very superior to the coils of pipes.

The fresh-air inlet, which, as far as I am able to learn, was first used at this Station, and which has proved of great practical value, consists of a 1½-inch pipe connecting the interior of the chamber with the external air. It is fitted to the top of the apparatus. The external opening of the inlet is covered with a strainer of fine brass netting, to prevent the entrance of foreign matter. The inlet is supplied with a valve, to open and close it. The entire chamber is encased in a 1½-inch layer of asbestos magnesia, which retains the heat in the chamber and prevents outside radiation. This it does in a very effective manner, the temperature of that portion of the boat in which the apparatus is placed being very little raised above that of adjoining apartments. The ends of the chamber open into rooms having absolutely no communication with each other, the infected end (Fig. 2) receiving the clothing removed from the disrobing-room adjoining. The disinfected end

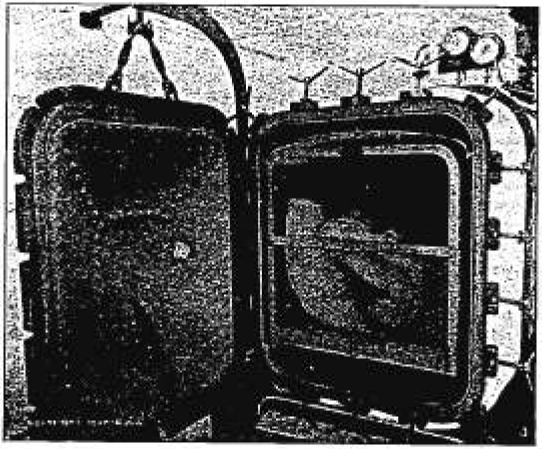
FIG. 2.



Infected end.

(Fig. 3) opens into an apartment from which the clothing is given directly to the owners, who have passed through the bath-rooms. The operation of disinfecting clothing, bedding, etc., with the steam-chamber is as follows: the materials to be treated are placed in the cradle or car in the infected end, which is seen in Fig. 2 (both ends of the chamber are never open at the same time), the door is then bolted, and a vacuum of about 20 inches is obtained by the steam-exhauster. This is secured in about one minute. The object is not only to remove the air from the chamber, but also the air and moisture from the material to be treated, which, forming a cushion, prevent the proper entrance of the steam. Steam is now allowed to enter the chamber, which it does very rapidly, producing a temperature of 230° to 240° F. within three or four minutes. My experience has been that 230° is the temperature that is needed for disinfection. This is unquestionably safe, and can be depended upon to kill all known micro-organisms which may be in clothing and other articles presented for treatment, provided there is an exposure of fifteen minutes to this degree of heat. At the expiration of this time—*i. e.*, after an exposure of fifteen minutes to a temperature of 230°—the steam-exhauster is again used, securing the same degree of vacuum (20

FIG. 3.



Disinfected end.

inches). This now removes the steam from the chamber and from the texture of the clothing, etc, undergoing disinfection, the latter being a most important consideration, as will be shortly shown. After the vacuum of 20 inches has been obtained the fresh-air inlet is opened and a current of fresh air allowed to pass through the chamber and its contents. This, it must be understood, is in conjunction with the steam-exhauster, which is still kept at work. The entrance of the air, of course, breaks the vacuum, but the exhauster carries the air rapidly through the chamber. After an exposure of eight or ten minutes to this treatment the door in the disinfected end is opened, and the clothing, etc., after being unrolled and exposed for five or six minutes, becomes dry and can be at once worn.

The degree of improvement in the drying-process, which is the result of the combined action of the steam-exhauster and the fresh-air inlet, can only be appreciated by one who has waited two or three hours or more for this same result. When it involves the detention of a ship at a quarantine-station its value is at once apparent. The importance of the rapidity with which this work is now performed and the materials dried is especially appreciated in the treatment of mail. Letters and papers treated with steam by the slower or older process were frequently injured by the disfigurement of the address and the unsealing of the letters. During the past three months the British India mail has been disinfected weekly at this station. The few letters which are sealed with wax, and packages containing books or other materials injured by heat, are set apart for disinfection by other methods and the remainder subjected to the process indicated above. So far, I have yet to see a letter the superscription of which has been affected, and very rarely have I found a letter unsealed or partly unsealed. This satisfactory result, I am certain, is due to the rapidity of action of the heat, and the use of the exhauster and fresh-air inlet afterward, which rapidly dries and prevents the spreading of the ink and the unsealing of the package.

The still more important and valuable effect of the vacuum is shown in the rapid and pronounced penetration which it insures. It gives a higher degree of temperature inside the packages, with a comparatively short exposure.

The first series of tests presented for consideration show the influence of the vacuum in steam disinfection. In all the experiments which I have made I constantly used packages of paper, inasmuch as this material probably offers as much (if not more) opposition to penetration as any with which we have to deal. In the tests made without vacuum, although the steam-exhauster is not used, the outlet which leads from the bottom of the apparatus and which allows the escape of water, the result of condensation, is opened for a moment after the chamber is closed, to allow a certain amount of the air contained in the chamber to be forced out by the incoming steam. This vent is imperative in carrying out the disinfection, as in an absolutely tight chamber the presence of all the confined air offers so much resistance that it is practically impossible to raise the temperature to the proper degree for disinfection. When the chamber is perfectly closed it frequently requires half an hour or more to get a temperature of 210° F.; whereas when the steam-exhauster is used 240° F. can be reached in three or four minutes, and where the air in the chamber is simply released by opening the conductor on the floor of the chamber above referred to, the same temperature (240° F.) is attained in about eight or ten minutes. This, however, does not answer the same purpose as the vacuum, which forcibly draws out the air contained in the chamber and its contents.

In the experiments about to be considered an accurately tested self-registering thermometer was placed in the centre of each package enumerated in the different experiments.

TABLE I.

Article.	Weight.	Subjected to degree of temperature.	Time of exposure.	Thermometer in package registered	
				With vacuum.	Without vacuum.
	Lbs.	°	Min.	°	°
Newspaper	1	240	3	240	200
Newspaper	2	240	3	210	160
Newspaper	2	240	3	210	160
Newspaper	3	240	3	200	110
Newspaper	3	240	3	200	111
Newspaper	3	240	3	220	120 (loosely wrapped)
1 cotton sheet	1	240	3	240	240
2 cotton sheets	2	240	3	239	237
1 double rose blanket	4	240	3	239	185
2 double rose blankets	8	240	3	203	110
1 ordinary house-rug	7	210	3	238	235
1 bag woollen clothing	7	240	3	173	108

TABLE II.

Article.	Weight.	Subjected to degree of temperature.	Time of exposure.	Thermometer in package registered	
				With vacuum.	Without vacuum.
	Lbs.	°	Min.	°	°
Newspaper	1	234	10	230	218
Newspaper	2	234	10	212	200
Newspaper	3	234	10	190	170
2 double blankets	8	234	10	215	190
2 sheets	2	234	10	230	229
1 bag woollen clothing	7	234	10	230	232

TABLE III.

Article.	Weight.	Subjected to degree of temperature.	Time of exposure.	Thermometer inside package registered
With vacuum:	Lbs.	°	Min.	°
Newspaper	1	240	10	240
Newspaper	2	240	10	232
Newspaper	3	240	10	200
2 cotton sheets . . .	2	240	10	240
2 double rose blankets . .	8	240	10	188
1 bag woollen clothing . .	7	240	10	230
Without vacuum:				
Newspaper	1	244	10	240
Newspaper	2	244	10	210
Newspaper	3	244	10	196
2 cotton sheets . . .	2	244	10	235
2 double rose blankets . .	8	244	10	195
1 bag woollen clothing . .	7	244	10	205

TABLE IV.

Article.	Weight.	Subjected to degree of temperature.	Time of exposure.	Thermometer inside package registered
With vacuum:	Lbs.	°	Min.	°
Newspaper	2	230	10	215
Newspaper	2	230	10	195
Newspaper	3	230	10	170
Without vacuum:				
Newspaper	2	227	10	133
Newspaper	2	227	10	174
Newspaper	3	227	10	120

It will be seen that the effect of the vacuum in favoring penetration is more apparent in short exposures. Where the exposure is longer the difference in the temperature, as shown by the thermometers inside the packages, is not so great. This is shown in Table I. In this table it is shown that the temperature inside a package of paper weighing two pounds was 210° F. after an exposure of three minutes with vacuum; while the temperature inside a package of the same weight without vacuum was only 160° F., a difference of 50° F.; whereas in Table II., after an exposure of ten minutes the difference in temperature inside of a package of paper weighing two pounds, with and without a vacuum, was only 120° F. It will be noticed that the effect of the vacuum is more decided in the three-pound packages of paper, or in any material where the resistance to the penetration of steam or heat is pronounced. This is also shown in Tables I. and II., where the thermometers were wrapped in cotton sheets, which are very easily penetrated; the temperature was about the same with and without vacuum. In Table I. a bag of woollen clothing showed a temperature inside the package of 172° F. with vacuum and 108° F., without vacuum; while in Table II. the temperature inside the bag of clothing was practically the same with and without vacuum, and about equal to the temperature of the chamber. In Table III. there is a marked difference between the test with a bag of clothing made with and without vacuum. These discrepancies are easily explained in this particular case: the clothing was simply pushed into the bag after the manner of sailors, and after each test the clothing was removed and aired again and placed in the bag for the succeeding test, and was not packed with the same degree of tightness in each instance, nor could the thermometer always be protected to the same extent. However, the advantage of the vacuum is shown in two of the three tests. In Table IV., where the experiments were made with packages of newspapers, the advantage of the vacuum is again evident.

It was meant that the temperature of the chamber should be the same in each instance where the tests with and without vacuum were to be compared; but occasionally the steam-pressure becomes somewhat unruly, and a difference of a few degrees is noticeable, as in Tables III. and IV. In these cases it was necessary to divide the tables. However, a fair comparison can be made.

It is frequently observed that the temperatures registered in packages of the same material and weight and subjected to the same temperature in different tests do not always agree. Thus, a package of newspapers weighing two pounds and subjected to a temperature of 240° F. for ten minutes may show an inside temperature of 230° or 232° F., while the temperature in the same test at another time will show a difference of 10° or more. This is due to the way of folding the package, which cannot be performed in exactly the same manner in each instance. If the material is more tightly wrapped, the temperature inside is correspondingly less. This occurs where the greatest care is exercised.

The results detailed in the preceding tables also indicate the importance of a sufficient duration of exposure. In Table I. it is shown that the temperature within a package of newspapers weighing two pounds, and subjected to a temperature of 240° F. for three minutes, was 210° F. with vacuum, whereas after an exposure of ten minutes to the same temperature it was 232° F. In the above experiments the steam-pressure in the chamber necessary to secure the temperature required (about 230° F.) was from eight to twelve pounds to the square inch. In the tests made with a perfectly tight chamber, with no release of the confined air, it was practically impossible to obtain a sufficiently high degree of heat. Even a comparatively low temperature required from half to one hour. In one instance, with a pressure of fifteen pounds to the square inch, a temperature of 202° F. only was reached in forty-five minutes; whereas, as already shown with the steam-exhauster, a temperature of 240° F. was reached in three minutes. In another test, without any vent in the chamber, 215° F. was reached in about the same length of time (less than an hour). I believe, therefore, it is unnecessary to consider further the process of disinfection as performed in a perfectly tight chamber.

In the investigation of steam disinfection it soon becomes apparent that as the degree of pressure in the chamber diminishes the penetration is correspondingly less. The following tables, V. and VI., will illustrate this. In these tests there was no steam-pressure in the chamber whatever, the indicator registering nothing. It will be seen by referring to Table I. that in the package containing two cotton sheets penetration was very easily effected, the thermometer inside the package being within four degrees of the temperature of the chamber (240° F.) after an exposure of only three minutes, while Table V. shows a difference of 48° F. between the temperature of the chamber (170° F.) and the temperature inside the package of sheets after an exposure of ten minutes. This marked difference is also seen in Table VI.

TABLE V.

Article.	Weight.	Subjected to degree of temperature.	Time of exposure.	Thermometer inside package registered
With vacuum:	Lbs.	°	Min.	°
Ordinary house-rug . .	7	170	10	100
Newspaper	1	170	10	137
Newspaper	2	170	10	120
Newspaper	3	170	10	107
2 double rose blankets . .	8	170	10	120
2 sheets	2	170	10	122

TABLE VI.

Article.	Weight.	Subjected to degree of temperature.	Time of exposure.	Thermometer inside package registered
Without vacuum:	Lbs.	°	Min.	°
1 rug.	7	200	10	105
Newspaper	1	200	10	160
Newspaper	2	200	10	120
Newspaper	3	200	10	100
2 double rose blankets . .	8	200	10	135
2 sheets	2	200	10	165

The results given in the above tables have been repeatedly verified by numerous tests of the same character.

These preliminary tests were regarded as necessary to the proper investigation of the effects of steam under the given conditions on the bacillus of the bubonic plague and the diphtheria and anthrax bacilli, the results of which are given below. In order that there should be no question as to the vitality of the micro-organisms used, the cultures were freshly prepared in each test by Dr. C. B. Fitzpatrick, who carefully maintained their virulence by inoculation of guinea-pigs and white mice. This procedure was carried on in connection with his work with the plague antitoxin, a report of which has recently been published in the *New York Medical Journal.* Sterilized linen disks soaked in bouillon cultures and enclosed in cotton, woollen, and paper envelopes, were placed inside the packages used in the different experiments.

It was found in all cases, where linen disks soaked in cultures of the bacilli of the above-mentioned diseases were placed in open Petri dishes and then laid on the floor of the cradle in the steam-chamber, and subjected to a temperature of 155° F. for fifteen minutes, that no growth occurred. I believe that it is safe to regard this temperature as causing the death of the bacilli in question in all cases under these conditions, although the germs were usually killed at a temperature of about 135° F. It is to be understood, however, that a temperature of 155° F. must reach the interior of the package. A chamber-temperature of this degree (155° F.) would probably show not more than 100° F. inside the package, and would be manifestly insufficient even with a long exposure. By referring to Tables V. and VI. it will be seen that in but two instances did the temperature inside the packages reach 155° F., and this occurred once in a package of one pound of newspaper and once in one composed of two sheets, where an exposure of ten minutes to a temperature of 200° F. was made. The packages were removed from the chamber in each experiment immediately after the exposure and the disks contained therein placed in tubes containing bouillon. The tubes were kept in the incubator for at least a week before a final decision as to the growth of the bacilli was made.

The facts secured in the first series of experiments (with thermometers) relative to penetration, etc., corroborate the tests made in the second series (with micro-organisms), and show that where the packages were subjected to low temperature growths frequently occurred; and although a lower temperature may cause the death of the micro-organisms subjected to it, it is unsafe to compute too closely the degree of heat necessary for germicidal action; therefore considerable margin should be allowed. For this reason I believe that a temperature of at least 155° F. must be secured inside the packages to be disinfected. The tests described above made with self-registering thermometers in the first series of experiments may be used as a guide. A study of the following tables shows that where packages containing infected disks were subjected to comparatively low temperature the results were variable. This is well shown in Tables VII. and VIII. (second series), where packages of the same material and weight were subjected to the same temperature and exposure (170° F. for ten minutes).

SECOND SERIES.

TABLE VII.—WITH VACUUM.

Temperature, 170° F. Time of exposure, 10 minutes.

Plague:	
1. Sheet of paper and envelope	No growth.
2. Newspaper, 1 pound	Growth.
3. Newspaper, 2 pounds	Growth.
4. Blanket	No growth.
Diphtheria:	
1. Sheet of paper and envelope	No growth.
2. Newspaper, 1 pound	No growth.
3. Newspaper, 2 pounds	No growth.
4. Blanket	No growth.
Anthrax:	
1. Sheet of paper and envelope	No growth.
2. Newspaper, 1 pound	No growth.
3. Newspaper, 2 pounds	No growth.
4. Blanket	No growth.

TABLE VIII.—WITH VACUUM.

Temperature, 170° F. Time of exposure, 10 minutes.

Plague:	
1. Sheet of paper and envelope	No growth.
2. Newspaper, 1 pound	Growth.
3. Newspaper, 2 pounds	Growth.
4. Blanket	Growth.
Diphtheria:	
1. Sheet of paper and envelope	No growth.
2. Newspaper, 1 pound	No growth.
3. Newspaper, 2 pounds	Growth.
4. Blanket	No growth.
Anthrax:	
1. Sheet of paper and envelope	No growth.
2. Newspaper, 1 pound	Growth.
3. Newspaper, 2 pounds	Growth.
4. Blanket	Growth.

Nothing can better illustrate the unreliability of a low temperature in steam-disinfection than the experiments shown in Tables VII. and VIII. The infected disks enclosed in paper and envelope show "no growth" in all the tests; beyond this there is no uniformity in the result, even where the disks were in a single newspaper. A reference to Tables V. and VI., where packages of similar material and weight (as used in Tables VII. and VIII.), and containing self-registering thermometers, were subjected to the same temperature and exposure, will present a satisfactory explanation of the irregular results shown in Tables VII. and VIII. It will be seen in the experiments in Tables V. and VI. that an inside temperature of 155° F. (which may be regarded as the minimum necessary to insure destruction of the bacilli) was reached in only two instances, both in Table VI., and, as might be expected, in material which practically offered the least resistance. (See Table VI., one pound of newspaper and two sheets.)

TABLE IX.—WITH VACUUM.

Temperature, 200° F. Time of exposure, 10 minutes.

Plague:	
1. Sheet of paper and envelope	No growth.
2. Newspaper	No growth.
3. Newspaper, 1 pound	Growth.
4. Newspaper, 2 pounds	Growth.
5. Blanket	No growth.
Diphtheria:	
1. Sheet of paper and envelope	No growth.
2. Newspaper	No growth.
3. Newspaper, 1 pound	No growth.
4. Newspaper, 2 pounds	Growth.
5. Blanket	No growth.
Anthrax:	
1. Sheet of paper and envelope	No growth.
2. Newspaper	Growth.
3. Newspaper, 1 pound	[1]
4. Newspaper, 2 pounds	Growth.
5. Blanket	Growth.

It is of great interest to note that in Table IX., where the temperature of the chamber in the test was increased to 200° F. (30° more than in the experiments recorded in Tables VII. and VIII.), that the germicidal action was more apparent. This is also shown in the following Tables, X., XI., and XII.

TABLE X.—WITH VACUUM.

Temperature, 200° F. Time of exposure, 15 minutes.

Diphtheria:	
1. Blanket	No growth.
2. Newspaper	No growth.
3. Newspaper, 1 pound	Growth.
4. Newspaper, 2 pounds	Growth.
5. Magazine, 200 pages, disks in middle near binding	Growth.

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[1] Tube of bouillon containing infected disk broken.

TABLE XI.—WITH VACUUM.

Temperature, 202° F. Time of exposure, 5 minutes.

Plague:	
1. Sheet of paper and envelope	No growth.
2. Newspaper, 1 pound	No growth.
3. Newspaper, 2 pounds	Growth.
4. Magazine, 160 pages, disks in middle near binding	No growth.

TABLE XII.—WITH VACUUM.

Temperature, 202° F. Time of exposure, 10 minutes.

Plague:	
1. Sheet of paper and envelope	No growth.
2. Newspaper, 1 pound	No growth.
3. Newspaper, 2 pounds	Growth.
4. Magazine, 160 pages, disks in middle near binding	No growth.
5. Blanket	Growth.

In Table XI., with an exposure of five minutes to a temperature of 202° F., the disks placed in the rolled blanket showed no growth; while in Table XII., with an exposure of double the time (ten minutes), the disks in a similar package (blanket) show a growth. This undoubtedly is the result of a difference in the degree of tightness with which the blanket was wrapped, and is often noticed where the test-articles have been exposed to comparatively low temperature; whereas with higher temperature given with shorter exposure no way in which a blanket or other package is rolled can interfere sufficiently with the penetration to prevent germicidal action. This is well illustrated in the experiments which follow, showing tests made with higher temperature.

In the following table the temperature of the steam-chamber was raised to 215° F., an increase of about 10° over that used in the experiments cited in Tables X., XI., and XII. For the first time we find the bacilli killed in all the packages.

TABLE XIII.—WITH VACUUM.

Temperature, 215° F. Time of exposure, 10 minutes.

Plague:	
1. Sheet of paper and envelope	No growth.
2. Book, 600 pages	No growth.
3. Newspaper, 1 pound	No growth.
4. Newspaper, 2 pounds	No growth.
5. Blanket	No growth.
Diphtheria:	
1. Sheet of paper and envelope	No growth.
2. Book, 600 pages	No growth.
3. Newspaper, 1 pound	No growth.
4. Newspaper, 2 pounds	No growth.
5. Blanket	No growth.

The anthrax-tests in this group of experiments are omitted, as unfortunately the labels of some of them were partially obliterated and made uncertain.

The following Tables, XIV., XV., XVI., XVII., XVIII., and XIX., are severe tests, inasmuch as they include packages of paper weighing three pounds. I do not believe that any material or bundle which might be presented for disinfection would be able to resist the penetration of steam to such an extent as some of the packages enumerated in the following tables, and I am firmly convinced from the experimental work and results gained in the foregoing experiments that a temperature of 230° F. in a steam-chamber, with an exposure of fifteen minutes, and the use of a vacuum will kill whatever vegetative organisms (and also probably spores) there may be in the material presented for disinfection, either at quarantine-stations or in public institutions. It is understood, however, that there should be a proper apparatus and that the work should be carefully done by a competent operator.

TABLE XIV.—WITH VACUUM.

Temperature, 230° F. Time of exposure, 5 minutes.

Plague:	
1. Newspaper, 16 pages	No growth.
2. Newspaper, 1 pound	No growth.
3. Newspaper, 2 pounds	No growth
4. Book, 600 pages	No growth.
5. Blanket	No growth.
Diphtheria:	
1. Newspaper	No growth.
2. Newspaper, 1 pound	No growth.
3. Newspaper, 2 pounds	No growth.
4. Book, 175 pages	No growth.
5. Blanket	No growth.
Anthrax:	
1. Newspaper, 16 pages	No growth.
2 Newspaper, 1 pound	No growth.
3. Newspaper, 2 pounds	No growth.
4. Book, 600 pages	No growth.
5. Blanket	No growth.

TABLE XV—WITH VACUUM.

Temperature, 230° F. Time of exposure, 5 minutes.

Plague:	
1. Sheet of paper and envelope	No growth.
2. Book, 600 pages	No growth.
3. Newspaper, 1 pound	No growth.
4. Newspaper, 2 pounds	No growth.
5. Blanket	No growth.

Diphtheria:

1. Sheet of paper and envelope	No growth.
2. Book, 250 pages	No growth.
3. Newspaper, 1 pound	No growth.
4. Newspaper, 2 pounds	No growth.
5. Blanket	No growth.

TABLE XVI.—WITH VACUUM.

Temperature, 230° F. Time of exposure, 10 minutes.

Plague:

1. Disks in book, 600 pages, book tied	No growth.
2. Disks in single blanket	No growth.
3. Disks in package of newspapers, 3 pounds	No growth.

TABLE XVII.—WITH VACUUM.

Temperature, 230° F. Time of exposure, 10 minutes.

Plague:

1. Almanac, 30 pages	No growth.
2. Magazine, 15 pages	No growth.
3. Magazine, 150 pages	No growth.
4. Book, 600 pages	No growth.
5. Newspaper, 2 pounds	No growth.

TABLE XVIII.—WITH VACUUM.

Temperature, 230° F. Time of exposure, 15 minutes.

Plague:

1. Sheet of paper and envelope	No growth.
2. Sheet of paper and envelope	No growth.
3. Newspaper, 1 pound	No growth.
4. Newspaper, 2 pounds	No growth.
5. Mattress (Mexican moss)	No growth.
6. Mattress (excelsior)	No growth.
7. Blanket	No growth.
8. Coats with disks in pockets	No growth.

TABLE XIX.—WITH VACUUM.

Temperature, 230° F. Time of exposure, 15 minutes.

Plague:

1. Newspaper, 2 pounds	No growth.
2. Newspaper, 3 pounds	No growth.
3. Blanket	No growth.

Diphtheria:

1. Newspaper, 2 pounds	No growth.
2. Newspaper, 3 pounds	No growth.
3. Blanket	No growth.

Anthrax:

1. Newspaper, 2 pounds	No growth.
2. Newspaper, 3 pounds	No growth.
3. Blanket	No growth.

Experiments similar to the above have shown that a temperature of 230° F., with an exposure of fifteen minutes, is also destructive to the spores of anthrax.

In conclusion, I would reiterate what I have already said, that in order to procure the desired results in steam disinfection careful attention should be given to the selection of the steam-chamber; that a temperature of 230° F. and an exposure of fifteen minutes are required; and that for quick and effective work a steam-exhauster should be provided. These requirements are particularly needed at quarantine and other public disinfecting-stations. At these places it is entirely impracticable to open packages and spread them out for exposure, consequently the matter of penetration must always be carefully considered. It will be seen in the tests made with low temperatures that the pressure in the chamber was practically zero, and, as might be inferred, the penetration was ineffective. If this is the result in a tight chamber, it cannot be expected that any safe or satisfactory result can follow where steam is indiscriminately introduced into a living-apartment or in a dwelling or on board a vessel. This I know has from time to time been advocated. I do not believe that a living-apartment or hold of a ship can be made sufficiently tight or can be subjected to a steam-pressure great enough to disinfect its contents properly. Leaks are sure to occur, which tend at once to render the steam ineffective as a germicide. If it should be desired to disinfect the hold of a ship, and steam should be selected as the agent, it is apparent that a temperature applied to the inner surface of the hull of the vessel below 155° F. would be unsafe to depend upon. There is no question that the organisms which would be found in an infected hold would, in part, rest upon the inner sides of the vessel. Wooden ships are becoming a thing of the past, and iron ones are being substituted. These rest in water the temperature of which is always low, and a superficial consideration will show that as the result of conduction the hull is always cold. I do not believe the low temperature of the hull can possibly be raised to a sufficient degree by the amount of steam which can be thrown into this part of the vessel, taking into consideration the numerous leaks which are always present. Fortunately, the ship's hold and cargo are rarely infected, and are too frequently subjected to a worthless disinfection.